REFINEMENT OF DISPRE2 QUANTITY-DISTANCE SOFTWARE

by

Patricia Moseley Bowles
Southwest Research Institute
P.O. Drawer 28510
San Antonio, Texas 78228-0510

and

Michelle Crull, PhD, PE
U.S. Army Engineering & Support Center, Huntsville
ATTN: CEHNC-ED-CS-S
P.O. Box 1600, Huntsville, Alabama 35805-4301

ABSTRACT

The DISPRE2 model, developed by Southwest Research Institute (SwRI), has been refined under a contract to the U.S. Army Engineering and Support Center, Huntsville, and the Klotz Club to allow final Klotz Club approval of the use of the model for loading densities less than or equal to 1.0 kg/m^3. DISPRE2 predicts the hazardous debris density and air blast at any given distance following an accidental detonation in an arch-shaped or rectangular above-ground ammunition magazine storing up to 5,000 kg of TNT equivalent explosives material. Version 1.0 of DISPRE2, completed in October 1994 for the Klotz Club (an informal working group composed of delegates from eight countries with common concerns in safe explosives storage) was introduced at the 1994 DOD Explosives Safety Seminar.   Subsequent expansion of the model was presented at the 1996 DOD Explosives Safety Seminar. Since that time, modifications and refinements have been recommended by a users working group which met in August 1996 and a technical working group meeting in December 1996. These changes have now been implemented into Version 2.5 of the software. Examples of the modifications include the incorporation of an updated version of the BLASTX code, changes to the shape of the debris density contours, refinement of the treatment of earth cover and debris roll, and the addition of input warning flags. All refinements to DISPRE2 Version 2.5 and their effects on the resultant output are presented in this paper.

1.0 INTRODUCTION

DISPRE2, Version 2.6, explosion hazards prediction software, is expected to receive approval for release for use in low loading density situations (Q/V less than or

Report Documentation Page

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
AUG 1998		**00-00-1998 to 00-00-1998**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Refinement of Dispre2 Quality-Distance Software	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
U.S. Army Engineering & Support Center, Huntsville,ATTN: CEHNC-ED-CS-S,P.O. Box 1600,Huntsville,AL,35805-4301	

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM001002. Proceedings of the Twenty-Eighth DoD Explosives Safety Seminar Held in Orlando, FL on 18-20 August 1998.

14. ABSTRACT
see report

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**12**	

equal to 1.0 kg/m^3) by the end of 1998. It provides the user with a user friendly and effective tool that will greatly aid in the safe siting of explosives storage magazines. The original DISPRE model for determining safe siting distances for protection from hazardous building debris was developed by Southwest Research Institute (SwRI) under funding from the U.S. Department of Energy (DOE) and the Department of Defense Explosives Safety Board (DDESB). This model has been proven effective for predicting building debris throw for charge weights up to 120 kg in a rectangular structure (Reference 1). DISPRE was expanded under a program sponsored by the Klotz Club, an informal group including delegates from eight countries (France, Germany, Norway, the Netherlands, Sweden, Switzerland, United Kingdom, and United States). The new version of the model, DISPRE2, covers arch-shaped and rectangular above ground ammunition magazines and hardened aircraft shelters storing up to 5,000 kg of TNT equivalent explosives material (Reference 2). Version 1.0 of this self-contained software, designed to run in a Windows environment on a personal computer, was first introduced at the Twenty-sixth DoD Explosives Safety Seminar in 1994 (Reference 3). Later modifications and validation results were reported at the Twenty-seventh DoD Explosives Safety Seminar in 1996 (Reference 4).

A users working group composed of representatives from each of the Klotz Club countries met in August 1996 to review DISPRE2, Version 2.0. Several areas of the software were identified for modifications or updates. A technical working group, assigned by the Klotz Club, met in December 1996 to further discuss the findings of the users working group and to refine the definition of the requested modifications. Representatives from Germany, the Netherlands, Norway, the United Kingdom, and SwRI attended this meeting. SwRI made some of the identified updates under a previous contract with the U.S. Army Engineering and Support Center, Huntsville (CEHNC) to produce DISPRE2, Version 2.5. SwRI has now completed the remaining updates and changes to DISPRE2 defined by the Klotz Club technical working group in December 1996. The modifications that are now in DISPRE2, Version 2.6 are described briefly in this paper.

2.0 SUMMARY OF WORK PERFORMED

2.1 Incorporation of Input Flags

As part of a previous task (Reference 5), SwRI reviewed the scenario setup screens of each structure type in DISPRE2 to determine where the user could exceed software limitations and recommended input warning and error flags. These input flags have now been incorporated within Version 2.6. Error flags require an acceptable change in the value by the user before the program will continue. Warning flags suggest the user may want to change a parameter because it is outside a typical range of values for that parameter, and the user can choose to change the parameter or leave it unmodified and continue.

Examples of the input flags now in DISPRE2 are illustrated in Figures 1 and 2. Figure 1 shows a component material properties input screen for a reinforced concrete component for a structure type 6 (non-earth covered, rectangular structure for small explosive quantities). Figure 2 indicates some of the flags for the explosive charges input screen for a generic arch shaped magazine (structure type 4). Each figure shows a copy of a selected setup screen with a summary table below it. The summary table indicates the parameter to be checked, the check to make, the software responses to a positive and negative check, and the wording for the flags. Similar checks are made for all input screens for the seven available structure types.

2.2 Wall Thickness and Weight

In previous versions of DISPRE2, the wall thickness was not internally coupled with the wall weight per unit area. The parameters were used in different modules, and separation of the parameters originally served a long, lost purpose. Knowledgeable users would couple the values through input; however, if this was not done, erroneous results were possible. The wall weight per unit area parameter is now calculated using the wall thickness and wall density so that all these parameters are coupled. A change in wall thickness now appropriately produces a change in the wall weight per unit area.

All scenario files included with the program installation disks (default and example files) have been changed to incorporate the coupling of wall (or roof) thickness and weight since new parameters were created. Any other scenario files created with previous versions of DISPRE2 will have to be changed to incorporate this change. The old scenario files should still run, but the results could be in error if the user fails to couple the wall thickness and weight per unit area on his own through the input. It is highly recommended that the user create all new scenarios utilizing the appropriate structure default files instead of attempting to change old scenario files.

2.3 Incorporation of New BLASTX

The DISPRE2 software includes executables for the BLASTX, SHOCK, FRANG, and MUDEMIMP codes, as well as numerous modules for intermediate calculations and results analyses. The first three codes are used in determining loads produced in structures from internal detonations. Some symmetry errors were discovered in the BLASTX code during several past DISPRE2 refinement tasks. Explosive charges centered within the plan of a rectangular structure did not always produce the same loads at symmetrically located targets. The modules in DISPRE2 in which target locations were calculated and set had been modified to include a temporary "fix" for this problem. However, a few configurations still could result in nonsymmetrical loads. These symmetry errors have now been corrected in BLASTX, Version 3.6.3, and verified by CEHNC (Reference 6). The U.S. Army Waterways Experiment Station (WES) provided SwRI with a new DLL file of the BLASTX, Version 3.6.3, executable. The DLL file for BLASTX, Version 3.6.3, has now been incorporated in DISPRE2, Version 2.6.

Structure Type 6 — Component Material Properties for Reinforced Concrete

Parameter	Check to be Made	Yes	No	Flag Wording
Component thickness	thickness>0	Proceed with secondary check below	Issue a flag. Do not proceed until check is 'yes'.	"Error: Thickness must be greater than zero. Enter a new thickness."
	15 <= thickness <= 120 (metric) 6<=thickness <=48 (English)	continue	Issue a suggestion flag and provide user chance to change. Program continues whether the value is changed or not.	"Warning: Typical values for component thickness are between 15 cm (6 in.) and 120 cm (48 in.). Enter a new value, if desired, or choose to ignore warning."
Rebar spacing	spacing>0	Proceed with secondary check below	Issue a flag. Do not proceed until check is 'yes'.	"Error: Rebar spacing must be greater than zero. Enter a new rebar spacing."
	10 <= spacing <= 60 (metric) 4<=spacing<=24 (English)	continue	Issue a suggestion flag and provide user chance to change. Program continues whether the value is changed or not.	"Warning: Typical values for rebar spacing are between 10 cm (4 in.) and 60 cm (24 in.). Enter a new value, if desired, or choose to ignore warning."

Figure 1. Example Input Error and Warning Flags for R/C Component Material Properties Screen
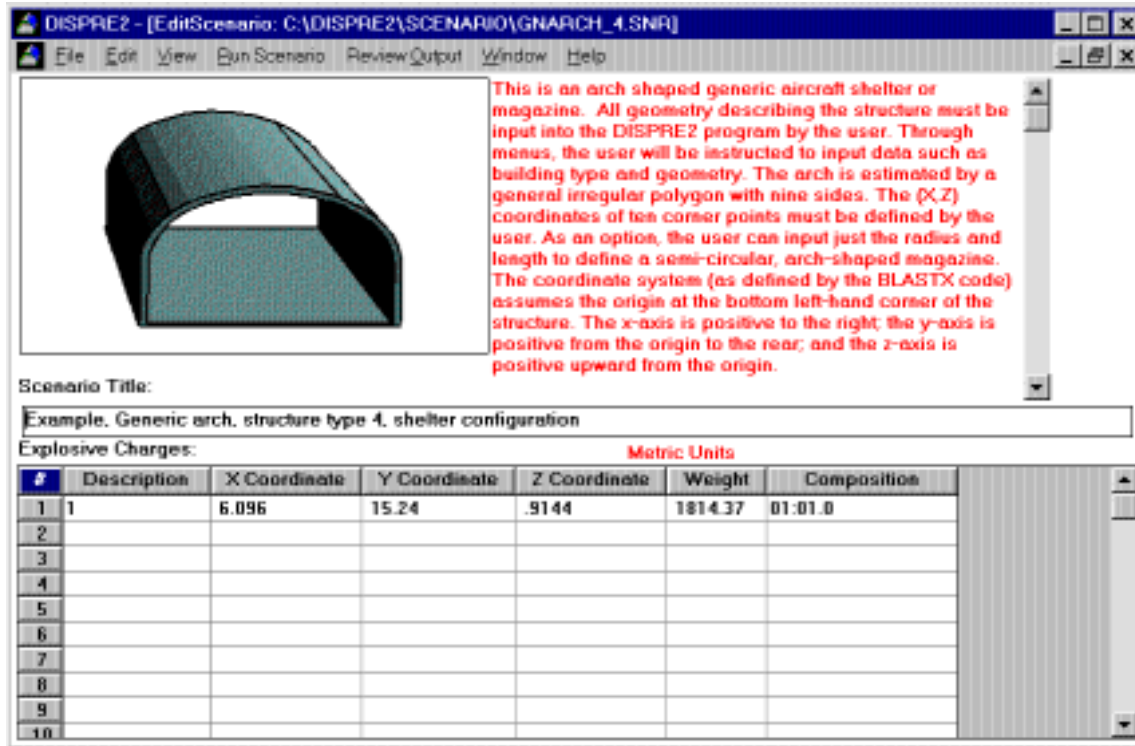
Structure Type 4 — Explosive Charges screen

Parameter	Check to be Done	Yes	No	Flag Wording
X Coordinate	X < XMAX	continue	Issue warning flag. Require a new X be entered. Do not proceed until check is 'yes'.	"Error: X value must be less than 'XMAX'. Input a new value for X."
Y Coordinate	Y < YL	continue	Issue warning flag. Require a new Y be entered. Do not proceed until check is 'yes'.	"Error: Y value must be less than 'YL'. Input a new value for Y."
Z Coordinate	Z < ZMAX	continue	Issue warning flag. Require a new Z be entered. Do not proceed until check is 'yes'.	"Error: Z value must be less than 'ZMAX'. Input a new value for Z."
Weight	W > 0	next check	Issue warning flag. Require a new W be entered. Do not proceed until check is 'yes'.	"Error: Charge weight must be positive number. Input new weight."
Weight	W < 5000 (metric) or W < 11,000 (English)	continue	Issue warning flag and continue.	"Warning: Code is not validated for W > 5000 kg (11,000 lb) for this structure type. Proceed with caution."

Figure 2. Example Input Error and Warning Flags for Explosive Charges Input Screen

2.4 Debris Distances for Earth Covered Magazines

Several reported disparities in predicted debris distances for earth cover increases have been examined. This task originated from comments from a TNO report (Reference 7) done for the DISPRE2 user's workshop in August 1996. Reference 7 indicated that there was increasing hazard distance with increasing earth cover for a rectangular structure and decreasing hazard debris distances with increasing earth cover for an equivalent volume arch shaped structure. However, it was discovered that the example in Reference 7 evidently used an arch shaped *shelter* in the calculations, not an arch shaped *magazine*. When a user chooses the generic arch (structure type 4), he can select it to be an aircraft shelter or a magazine. SwRI ran very similar cases to those reported in Reference 7 and found that, for both arch shaped and rectangular *magazines*, increasing earth cover increased the hazard distances. In fact, the side and rear distances (which are calculated based on an empirical method for predicting soil debris throw from underground explosions) are the same for a rectangular or arch shaped magazine for the same volume and earth cover, as should be expected considering how these are calculated. Earth cover does not figure into the calculations for debris throw from the front wall; however, the loads and, thus, velocities and throw distance are somewhat different between the arch and the rectangular structures. For an arch shaped generic *shelter* (structure type 4 defined as a shelter), the front debris throw again remains the same, but the side and rear distances decrease with increasing earth cover. After close examination, it was determined that the comparisons made by TNO in Reference 7 were comparing a structure type 4 *shelter* and a structure type 5 *magazine*, instead of all magazines. As discussed at numerous Klotz Club meetings, the methodologies used to determine side and rear distances for shelters and magazines are quite different (a 3-step loads/initial debris parameters/debris throw approach vs. soil debris throw method).

Until further data are available for the debris throw from earth covered magazines, it is difficult to assess which approach is best for these magazines. At the time of model development, though, the available data matched the soil throw methodology a little better (Reference 2). The disparity noted by TNO is due to a comparison between shelters and magazines. Thus, no change has been made to DISPRE2 for this task. The disparity that exists between the methods used for shelters and magazines should be resolved, but not without additional magazine debris throw data.

Along these same lines, Reference 7 also makes comparisons of hazard debris distance predicted when varying the wall thickness and the wall weight/area. Since the soil debris throw method used to predict distances to the side and rear of earth covered magazines is independent of wall thickness, a change in wall thickness will not produce a change of distance. However, a change in wall thickness will now cause a change in distance to the front because the thickness is coupled with the wall weight. Regarding the perceived changes when wall weights were changed in Reference 7, the author again defined arch shaped *shelters*, not *magazines*. Thus, they saw changes in distance for front, side, and rear when wall weight changed. When an earth covered *shelter* is defined and wall weight is varied, debris throw distances in all directions are affected. When an earth

covered *magazine* is defined, the front distance will change with changes in wall weight, but the side and rear distances will remain the same due to the soil throw method used to predict debris distance for these structures.

2.5 Debris Roll

All seven default scenarios and all seven examples included with the installation disks for DISPRE2 have been modified to make debris roll a changeable parameter to permit users to disable roll. This will allow users to investigate the effects of roll on their results. If no changes are made, roll is always turned on for aircraft shelters. It is always on for magazines as well, unless a barricade is defined; then roll is turned off.

Text has been included within the software that will be activated when a user turns off the debris roll parameter. The text reminds the user that roll has been turned off and that roll should normally be enabled. The text concludes by warning the user that the distances calculated are not final debris stopping distances. Warning messages will appear both in the edit mode when the user changes the roll parameter and in the output summary if roll has been disabled.

2.6 Effects of Structural Form

SwRI checked the drawings and descriptions for the third generation Norwegian/US shelter (structure type 1), the third generation US shelter (structure type 2), and the third scale PAS tests which were scaled versions of the Norwegian/US shelter. All these aircraft shelters are constructed with ground beams or ties, with one exception. When the third generation Norwegian/US shelter is built on bedrock instead of soil, no tie beams are used. All tests on the structures appear to have been on shelters constructed with ground beams. A review of the drawings of the third generation Norwegian shelter (structure type 3) and communication with the Norwegian Defence Construction Service (NDCS) indicate these shelters are also constructed with tie beams, and they all have foundations on soil. Communication with Arnfinn Jenssen of NDCS concerning the 1:20 and 1:100 scale tests of the third generation Norwegian shelters indicated these models were constructed without tie beams. However, Mr. Jenssen also said the full scale ones do not have tie beams per se. Since the sidewalls are vertical walls, there is no static requirement for tie beams. The shelters do have heavy reinforcement in the floor, but not actually tie beams. Text has been added in the software to indicate the limits relating to these structural forms.

2.7 Barricade Option Clarification

The user of DISPRE2 can select a barricade option if his structure indeed has some type of barricade or berm in front of any of the walls. The program does not actually define a barricade as a geometric entity. It does, however, adjust debris throw distances if the barricade option has been selected. The results of using the barricade option have been clarified in Version 2.6. For structure types 4 and 5 defined as

magazines with a barricade, the last paragraph in the output summary was replaced with the following:

> The barricade option has been selected for the front of the magazine. When a barricade is provided to the front of a magazine, debris from the headwall and the door will likely be redirected. At this time, DISPRE2 does not explicitly model debris impact with a barricade when the barricade option is selected in the input. For loading densities less than 0.08 kg/m^3, limited comparison to data indicates door and headwall debris are redirected through an approximate angle of 90 and come to rest in an extension of the surface area between the headwall and barricade. The distance calculated to the front should be used to the side in the area between the headwall and the barricade.

> For loading densities greater than 0.08 kg/m3, DISPRE2 does not predict any effect of a barricade on debris because supportive data are not available for such predictions.

2.8 Shape of Debris Density Contours in Output

During the initial development of the DISPRE2 software (Reference 2), it was understood that there existed areas of low debris density out from the corners of structures rectangular in plan following an accidental internal detonation. As indicated in Reference 2, a number of researchers have observed this effect. However, the data are too limited to quantify an exact shape of a debris density contour in these areas. For this reason, all previous versions of DISPRE2 used oval shaped debris density contours, drawn simply by using the maximum hazardous distance in each direction and fitting an ellipse to the four points. In an effort to better indicate that lower densities exist in the corners, the debris density contours have been modified to show shaded areas out from the corners. The outer contours are still drawn as an ellipse. The shaded areas are drawn five degrees off from the normal to each structure surface edge to define four shaded "pie shaped" areas. An example of the refined debris density contour output is shown in Figure 3. Text has been added in the "Output Summary, Debris Density Contour" screen to indicate "debris density in shaded areas is probably less; however, insufficient data exist to fully quantify the value".

2.9 Limitations of Earth Covered Magazines

SwRI has incorporated a warning flag in DISPRE2 that includes a statement of the data limitations for the earth-covered magazines (structure types 4 and 5 defined as magazines, not shelters). The exact wording of the flag was provided by CEHNC. The flag appears whenever the user tries to run a scenario for a structure type 4 or 5 (defined as a magazine) with a total charge weight exceeding 225 kg (500 lb). The first tier, or screen, appears in bold, red lettering to warn the user of the charge weight limitation for these structures. The available test data for these structures set the limitation. The user is given the option of continuing with the current charge weight, changing the charge
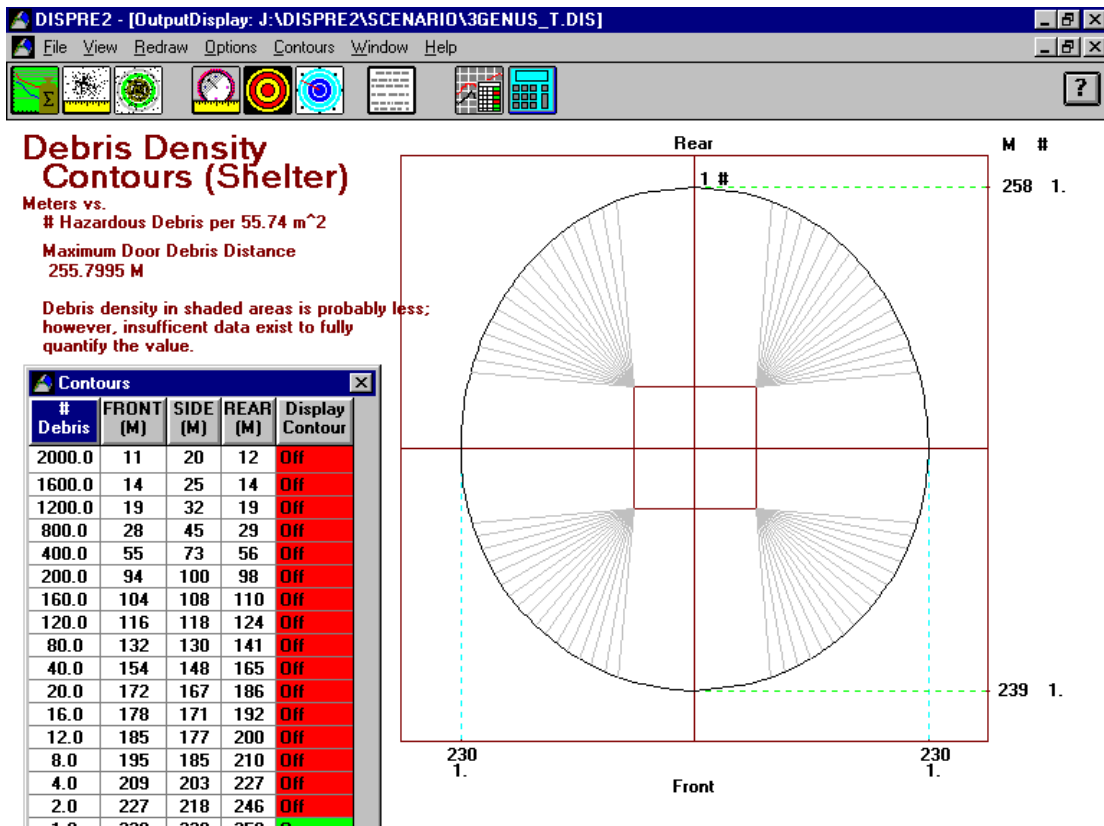
Debris Density Contours (Shelter)

Meters vs.
Hazardous Debris per 55.74 m^2

Maximum Door Debris Distance 255.7995 M

Debris density in shaded areas is probably less; however, insufficent data exist to fully quantify the value.

Contours

# Debris	FRONT (M)	SIDE (M)	REAR (M)	Display Contour
2000.0	11	20	12	Off
1600.0	14	25	14	Off
1200.0	19	32	19	Off
800.0	28	45	29	Off
400.0	55	73	56	Off
200.0	94	100	98	Off
160.0	104	108	110	Off
120.0	116	118	124	Off
80.0	132	130	141	Off
40.0	154	148	165	Off
20.0	172	167	186	Off
16.0	178	171	192	Off
12.0	185	177	200	Off
8.0	195	185	210	Off
4.0	209	203	227	Off
2.0	227	218	246	Off

Rear

Front

Figure 3. Example Debris Density Contours Output from DISPRE2, Version 2.6

weight, or requesting more information. If the user chooses to request more information, a second screen provides more details on the limitation and why the user should be warned. Essentially, the message conveys that predicted hazardous debris distances for conventional earth covered magazines with charge amounts exceeding the limit must be considered as approximate until further validation and test data become available. After reading the second screen, the user can then continue with the current charge weight or choose to change it. Scenarios that exceed the limits can still be run, but the user is at least warned about the limitations.

2.10 Additional Tasks Accomplished for Version 2.6

The main modifications to DISPRE2 have been described in Sections 2.1 through 2.9. Several other items were reviewed and/or modified within the software as well. The vent perimeter for a non-earth covered magazine (structure type 7) has been modified to account for venting through the breakup of the walls, as well as between the walls. Default and example files for structure type 7 were modified to reflect more typical non-earth covered rectangular magazines. Some of the parameters for the third generation U.S. aircraft shelter (structure type 2) have been changed in Version 2.6. Discrepancies noted at the DISPRE2 users workshop (Reference 8) were examined and resolved. The

calculations in Reference 8 were more exact in calculating volume, including the deviations in the corrugated metal liner of the shelter. SwRI had previously used the volume calculated by BLASTX for the defined arch structure. Changes have now been made to the volume, wall thickness, door weight, door area, and door perimeter for the default file for a structure type 2 to agree with the values in Reference 8.

Additional changes involved adding to the input screen descriptions for new scenarios to indicate whether a particular aircraft shelter structure type is normally earth covered or not. This question was raised because the third generation U.S. aircraft shelter (structure type 2) is not typically earth covered. The shelters identified as structure types 1 and 3 (Norwegian/US and third generation Norwegian) both normally have earth cover. Thus, the default for a structure type 2 is now no earth cover, whereas the appropriate earth cover thickness is used as the default for types 1 and 3. Finally, the calculation of debris velocities was reviewed to confirm that a maximum velocity is being determined from the initial loads, not an average velocity. The velocity is calculated from the maximum total shock and gas impulse over a given number of targets on a particular component and is, thus, a maximum velocity. An average velocity and a standard deviation are then calculated from this maximum to define the velocity distribution that will then be used to calculate trajectories for debris from that component.

2.11 Modification of "Help" Screens

After the above tasks had been completed, the "Help" documentation was reviewed to determine necessary changes due to software modifications. Changes have been made to the system requirements, the structure type descriptions (accessed by "Choose Structure"), the example given for the "Edit Scenario" window, and the example for the "Debris Density Contours View" in the "Output Display" window. All other information still applies to Version 2.6 without changes.

3.0 VERIFICATION OF DISPRE2, VERSION 2.6

The default and example scenarios for all seven structure types have been rerun (1) to make certain they are properly defined and therefore run properly for Version 2.6, and (2) to compare new results with results from Version 2.5. All these scenarios run with no errors and produce reasonable results. The hazardous debris distances have changed in the manner expected due to modifications made within the software to accomplish the tasks described herein. Numerous other scenarios (and partial scenarios) have been run to fully check out the input flags to determine if they are working as designed. A significant amount of time was spent doing this to check (and re-check after discrepancies were noted) every possible consequence of an erroneous entry in any of the input screens. As noted in Section 2.1, a number of modifications to the originally recommended flags became necessary as this detailed check procedure progressed. Although the checking of input within the software was even more complex than anticipated, this feature will greatly aid the user in creating realistic, usable scenarios.

In addition to the scenarios described above, existing scenarios for which specific problems had been previously noted were recreated and rerun as modifications were made to correct those problems. SwRI also ran as many scenarios as possible after all modifications had been made to the draft Version 2.6 software. It was not possible to rerun every scenario sent to us by Klotz Club delegates and designated testers because each scenario had to be recreated "from scratch" once certain modifications had been made. In some cases, it was not possible to determine the value previously used for all input parameters from the documentation. However, scenarios were created (or recreated) to test out each modification to the software. Included in these scenarios were each of the symmetry problem scenarios tested by CEHNC in the study summarized in Reference 6.

4.0 CONCLUSIONS

The DISPRE2 software has been reviewed as defined by the Klotz Club technical working group in December 1996. DISPRE2, Version 2.6, reflects the updates and changes necessary to complete the tasks described in Section 2.0, thus meeting the primary objective of this contract with CEHNC and the Klotz Club. These refinements are expected to result in final Klotz Club approval of the use of the model for loading densities less than or equal to 1.0 kg/m^3.

5.0 REFERENCES

1.   "Prediction of Building Debris for Quantity-Distance Siting", Department of Defense Explosives Safety Board Technical Paper No. 13, April 1991.

2.   Bowles, P.K., Oswald, C.J., and Polcyn, M.A., "Earth Covered Ammunition Magazines Quantity-Distance Model, DISPRE2", Final Report, SwRI Project 07-5394, prepared for the Klotz Club: France, Germany, Norway, Sweden, United Kingdom, Switzerland, and United States, October 1994.

3.   Bowles, P.M. and Oswald, C.J., "Earth Covered Ammunition Storage Magazines Quantity-Distance Model, DISPRE2", Twenty-sixth DoD Explosives Safety Seminar Proceedings, Miami, FL, August 1994.

4.   Bowles, P.M., "Validation and Expansion of DISPRE2 Quantity-Distance Model", Twenty-seventh DoD Explosives Safety Seminar Proceedings, Las Vegas, NV, August 1996.

5.   P.K. Bowles and D.G. Butts, "Update of DISPRE2 Software", Final Report, SwRI Project 06-1006, prepared for U.S. Army Engineering and Support Center, Huntsville, and the Klotz Club: France, Germany, the Netherlands, Norway, Sweden, United Kingdom, Switzerland, and United States, Contract No. DACA87-97-P-0310, September 1997.

6.   Michelle Crull, PhD, PE, and Douglas Grant, "Testing of BLASTX Software for Symmetrical Solutions", U.S. Army Engineering and Support Center, Huntsville, HNC-ED-CS-S-97-6, September 1997.

7.   R.J.M. van Amelsfort, "Evaluation of DISPRE2, an Earth-Covered Ammunition Magazines Quantity-Distance Model", TNO Prins Maurits Laboratory, Report No. 96D2/1281, July 1996.

8.   M.J.G. Connell and P.W. Friend, "Matching of DISPRE2 and Manual/Computer Analysis Methods with HAS 'DISTANT RUNNER' Trials", prepared for Explosive Storage & Transport Committee, London, TBV Consult Report No. 104444/0008/MC/PF, July 1996.